

# Teacher's Guide to FOSSIL MYSTERIES Guide to Evolution in San Diego

## **How to prepare your class for their tour:**

Log on to the Museum's website: [sdnhm.org](http://sdnhm.org), and navigate to the Education link. Click on the *Fossil Mysteries* Online Exhibition Guide. Here you will find information to help you and your students prepare for your field trip. Students should have some background in geologic time periods, fossils and how they form, and at least a basic introduction to the concepts of adaptations, mass extinctions, natural selection, survival of the fittest, common ancestors, and descent with modification.

## **The tour itself:**

The field guide can be completed in about an hour or two, ideally with students working in teams. The guide is divided into sections that correspond with the

major divisions of geologic time that the exhibition travels through. Questions for each time period of the exhibition are headed with the same title that is displayed on the informational sign: for instance: "A new menu for dinosaurs." Some questions can be answered by reading the sign and observing the display. Others require making inferences and using critical thinking.

## **Follow up:**

Using the Museum's Fossil Mysteries website, [sdnhm.org/archive/exhibits/mystery/](http://sdnhm.org/archive/exhibits/mystery/) you can follow up the field trip with a review of the displays and discussions about the questions on the field guide.

## **Answer Key ■**

## Cretaceous (144–65 MYA) Dinosaurs Rule!

**Predator or prey?** Describe some features of each dinosaur that identify it as predator or prey.

Albertosaurus

vs

Lambeosaurus

- Large conical teeth, claw-like “fingers, long muscular legs
- Stiffened tail, strong hind limbs, low tightly packed rasp-like cheek teeth, padded front feet

### A new menu for dinosaurs

How did discovering the diet of hadrosaurs help scientists learn about the evolution of grasses?

- After determining hadrosaurs’ impressive rows of grinding teeth were well adapted to chewing grasses, scientists also found grass in fossilized dung. This helped pinpoint the evolution of grasses to the time frame in which these dinosaurs lived.

How do you think the evolution of flowering plants (including grasses) influenced the evolution of dinosaurs?

- The inference that students will hopefully come up with is that dinosaurs were able to thrive amid the abundance of food provided by the emergence of the flowering plants including grasses.

## Cretaceous-Tertiary Boundary Event (65 MYA) Sudden Impact!

### Now you see them now you don’t

How did mammals (like the ancient opossum-like animal seen in the display) survive the event and why did they evolve so rapidly afterwards?

- They were able to take shelter in underground burrows. Being small, they were able to survive with less food. Students should make the inference that with the dinosaurs gone, there were fewer predators, thus allowing mammals to evolve rapidly.

Why do scientists think dinosaurs became extinct after the impact event?

- The large amounts of dust created by the asteroid impact blocked the sun, eventually causing plant life to die off, destroying the food chain and dooming the dinosaurs and large swimming and flying reptiles as well.

## Eocene (55–34 MYA) Entering the Age of Mammals

### Gnawing their way to the top

Explain the advantage that allowed rodents to evolve to represent 40% of all mammal species.

- Their ever-growing incisors can gnaw through tough seed husks, pods and shells, giving them a very diverse diet. They can find food just about anywhere.

### Welcome to Eocene San Diego

Name three types of organisms that lived in San Diego during this time, but no longer exist here. What do you think happened to cause them to die out?

- Mangrove trees, crocodiles, boas, and tortoises are a few examples from the display sign. Other examples are protoreodon, the ancient primates, tapocyon, tapirs, lemurs and brontotheres.  
Students should infer that climate change from the tropical forest environment to a drier climate caused these animals to die out.

### Taking hold in the trees

**Primate Family Tree** How many species of primates lived in San Diego during the Eocene?

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How do you think the tropical forest environment influenced the evolution of primates?

- Through the process of natural selection, primates evolved that were better adapted to living in trees. Primates had features such as grasping feet and hands, larger brains, binocular vision, and tails.

What characteristics do humans share with ancient primates?

- Binocular vision, larger brains, grasping hands.

## Oligocene (34–23 MYA) From Forests to Grasslands

### Runners from the past/Run for your life

How did the ankle and foot evolve between the extinct plant eater and the modern deer?

- The foot bones became fused allowing greater running speed and agility.

How could this be used as an example of survival of the fittest?

- Individuals that had the fused foot bones were able to outrun predators, survive long enough to reproduce and pass on their genes for fused foot bones to their offspring.

### Evolution transformed these arm bones

Which bones are they?

Blue \_\_\_\_\_ Orange \_\_\_\_\_

Green \_\_\_\_\_ Yellow \_\_\_\_\_

Describe how the arm bones evolved to suit each lifestyle. How are the bones different in each example and how does this help the animal either swim, climb, or run?

#### Swimmer

- For streamlined lifestyle in water: have paddle-like limbs with limited wrist rotation for swimming, hand is modified into a paddle.

#### Climber

- For flexible movement: ball and socket joint allow full range of motion, flexible wrist joints and long hands for grasping and hanging.

#### Runner

- For speed: joints allow fast forward motion and limit twisting, changes to ankle limit foot's range of motion, lower leg bones are longer, toes are smaller.

(Go straight through the hall and bypass the geology display on your right)

## Pliocene Epoch (5–2.5 MYA) “The Bay”

### Clam Sucker/Fish Chaser (walrus fossil skulls)

Examine the two walrus skulls and describe how they are different. How did the skulls help scientists determine the lifestyles of these extinct marine animals?

- The skull of *Valenictus chulavistensis* has no teeth in its lower jaw and only large canines in its upper jaw. These features and its narrow and arched palate suggest that it used its tongue as a piston and fed by sucking clams out of their shells. The skull of *Dusignathus seftoni* has a full mouth of teeth that would be ideal for feeding on fish and squid. These two walrus species could live in the same area because they had different diets.

Which species of fossil walrus is more closely related to the modern walrus? How do we know?

- The clam sucker, because the modern walrus has a similar lifestyle being a shallow diving suction feeder.

### A feast of familiar fish

Why have the fish in San Diego Bay not changed much since the Pliocene? How do we know?

- Fish evolve very slowly; scientists know this by examining fossil and genetic evidence.

### Giant predators hunt tiny prey

How did scientists use the feeding habits of modern gray whales to nickname the ancient gray whale the “vacuum cleaner”?

- Modern gray whales feed by sucking in sediment and tiny crustaceans (amphipods) living on the sea floor and then pumping the water and mud out through their baleen, trapping the prey in their mouths. Although no baleen was found with the ancient gray whale, the roof of the mouth preserves boney features showing where the blood vessels were that nourished the baleen plates.

### World changes shape the sea cow

What changes in their environment caused giant sea cows to evolve to lose their teeth?

- The sea cow that lived here 3.5 million years ago was adapted to the cold waters of the North Pacific Ocean, where it fed on soft kelp that didn't require teeth to chew.

## **Pleistocene (2.5 MYA–10,000 years ago) BIG Mammals!**

### **A fierce competition**

Why do we think lions became extinct in the Americas and Europe but survived and continued to evolve in Africa and Asia?

- Perhaps they became extinct in the Americas and Europe because of competition with humans for space and resources. They may have survived in Africa and Asia due to the fact that humans evolved alongside the big cats, especially in Africa.

### **A mystery in history 1796**

How did the “father of paleontology”, Georges Cuvier, realize this animal was extinct and thus represented the first example of extinction?

- It was too large to be from a modern animal. He couldn't match it up with any living species.

Why do you think modern sloths evolved to live in trees, instead of on the ground?

- Students may infer that there was a niche for sloths in the trees where they could find food, shelter and safety from predators.

### **Going, Going...Gone**

What are the two most popular theories as to why mammoths, mastodons and other Pleistocene “megafauna” became extinct?

- Overhunting by humans: The Overkill hypothesis.
- Climate change.